

SAMARKAND SULCI, ENCELADUS: TOPOGRAPHY AND GEOLOGY FROM THE DATA OF THE CASSINI 228EN NON-TARGETED FLYBY IN GLOBAL CONTEXT. R. J. Wagner¹, B. Giese¹, N. Schmedemann², K. Stephan¹, J. Voigt¹, P. Helfenstein³, E. Kersten¹, T. Roatsch¹, R. Jaumann¹, and C. C. Porco⁴; ¹Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany (Email: roland.wagner@dlr.de); ²Institute for Geological Sciences, Free University Berlin, German; ³Dept. of Astronomy, Cornell University, Ithaca, N.Y., USA; ⁴Space Science Institute, Boulder, Co., USA.

Introduction: Cassini, in orbit around Saturn since July 2004 and now in its final year, has performed numerous targeted and non-targeted flybys at the cryovolcanically active moon Enceladus. In a non-targeted flyby carried out on Dec. 19, 2015, images with 65 m/pxl spatial resolution were taken with the ISS narrow angle camera (NAC) [1] from the *Samarkand Sulci* region. This region, located in the Aziz Quadrangle (Se-10) [2] was chosen as area of interest for geologic, stratigraphic and topographic studies.

Procedure: The global geologic map by [3], and work using a global ISS image basemap [4][5] provided the context for this study. For detailed geologic mapping a mosaic of images from the non-targeted flyby 228EN (target areas: ENCELOUTB001) at 65 m/pxl spatial resolution was created. We adopted the unit designations given by [3]. In parts, unit boundaries were modified, taking into account the higher resolution of the 228EN data. A digital elevation model (DEM) could be derived using these imaging data [6]. Relative ages of geologic units are inferred from mutual crosscutting or superposition. Surface ages were also obtained from crater counts, using chronology models by [7][8] (see also discussion of cratering chronology models in the outer Solar System by [9][10]). Ages from crater counts are comparably uncertain because of the generally low crater densities (except in the densely cratered units) and of the small areas of measurement.

Stratigraphy – global context: In a previous work, we carried out crater counts on global scale in order to show potential correlations of surface geology with particle sizes of water ice [4]. For an update, mapping units from [3] were used in a more recent campaign [5]. In both campaigns it was found that the largest particles occur in the youngest units while the older densely cratered areas are characterized by smaller particles [4][5]. Crater distributions, measured in densely cratered units and in tectonically resurfaced areas as in, e.g., *Samarkand Sulci*, are shown in Fig. 1. The diagram shows that the crater densities in the relatively young tectonized areas are about one order of magnitude lower than in the cratered plains.

Flyby 228EN images – topography and stratigraphy: The digital elevation model (DEM) derived from the 228EN imaging data reveals remarkable differ-

ences in topography. One block (located above the center in the anaglyph shown in Fig. 2) is elevated by 1750 meter with respect to the surrounding terrain [6]. Stratigraphic relationships of the geologic units mapped in the 228EN hi-res data are shown in cumulative crater size diagram in Fig. 3. The *Samarkand Sulci* (curvilinear terrain 1 according to [3]) cut through densely cratered plains. Here, this unit was subdivided into a lineated facies (green symbols in Fig. 3) and a topographically elevated (ridged) facies (blue symbols). Isochrone lines shown in Fig. 3 are obtained by fitting the chronology function by [8] to measured crater distributions.

Summary: The sequence of geologic events that have taken place over a considerable period of time in the *Samarkand Sulci* region is reflected in significant differences in crater densities which range over about two order of magnitudes (from the highest to the lowest isochrone line in Fig. 3). In the 228EN high-resolution data, crater densities in individual areas of measurement within *Samarkand Sulci* are not very well separable from one another due to small-number statistics of superimposed impact craters. The cratering model ages according to the model by [8] generally are older and may date back to a period of 4.1 Ga ago when the densely cratered plains were formed. *Samarkand Sulci* may have formed 3.6 Ga ago an age with local resurfacing ages of ~500 Ma. The cratering model by [7] distinguishes two cases, Case A and B (see discussion in [7][9][10]), with Case A yielding higher model ages. In Case A, model ages of the old densely cratered plains are comparable to those by [8] (> ~4.1 Ga) and also similar to model ages of other densely cratered surfaces on icy satellites. The tectonized units of *Samarkand Sulci* were formed ~650 Ma ago, with local resurfacing documented in the youngest units to be on the order of ~50 Ma years old. According to Case B [7], densely cratered plains were formed ~2 Ga ago – which would leave a period of >2 Ga of Enceladus' geologic history unrecorded – while the tectonic event creating *Samarkand Sulci* took place ~100 Ma ago, with tectonic resurfacing going on until ~5 Ma ago. The present-day active cryovolcanism of Enceladus favors younger model ages for the tectonic resurfacing obtained with the chronology model by [8] to be more likely. Formation of the densely cratered units in

the distant past some 4 Ga ago is compatible with both chronology models [7][8] (Case A for the latter).

References:

[1] Porco C. C. (2004) *SSR*, 115 363–497. [2] Roatsch T. et al. (2013) *PSS*, 77, 118–125. [3] Crow-Willard E. N. and Pappalardo R. T. (2015) *JGR*, 120, doi:10.1002/2015JE004818. [4] Jaumann R. et al. (2008) *Icarus*, 193, 407–419. [5] Jaumann R. et al. (2011) *EPSC abstracts*, Vol. 6, abstr. No. EPSC-DPS2011-435-1. [6] Giese B. et al. (2017), *paper in preparation*. [7] Zahnle K. et al. (2003) *Icarus*, 163, 263–289. [8] Neukum G. et al. (2006) *EPSC Abstracts*, Vol. 1, abstr. No. EPSC2006-A-00610. [9] Dones L. et al. (2009) in: *Saturn from Cassini-Huygens*, Springer Publ., pp. 613–635. [10] Kirchoff M. R. et al. (2017) *submitted*, to be published in the LPI/UA/Space Sci. Series.

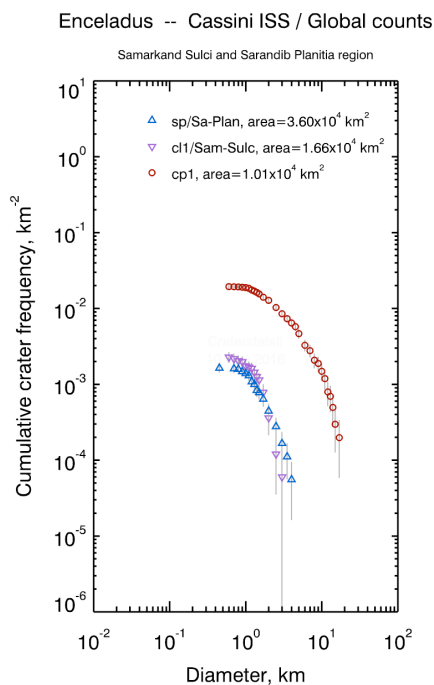


Figure 1. Cumulative crater size diagram of geologic units measured on a global context image base-map [1][2][4][5]. The diagram shows a distribution measured in old densely cratered plains (red circles) compared to the tectonized areas of *Samarkand Sulci* (inverted triangles, violet) and *Sarandib Planitia* (triangles, blue).

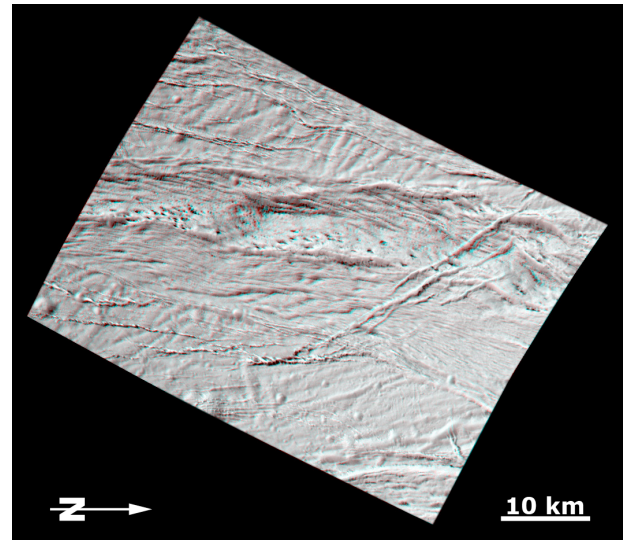


Figure 2. Stereo anaglyph from imaging data of the 228EN flyby, target site ENCELOUTB001.

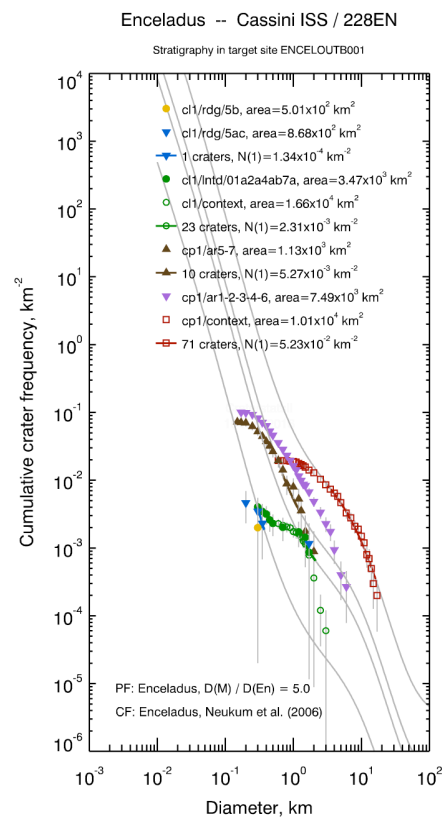


Figure 3. Cumulative crater size diagram showing stratigraphic relationships obtained with high-resolution images of the ENCELOUTB001 target area, flyby 228EN. Measurements from hi-res data are shown by filled symbols. Comparison with global counts by [4][5] are included (open symbols). Further explanation is given in text.